STATE OF MONTANA
ENVIRONMENTAL QUALITY COUNCIL
STATE CAPITOL
HELENA, MONTANA

COAL DEVELOPMENT POTENTIAL IN EASTERN MONTANA

by Thomas J. Gill
Research Assistant
January 7, 1972

Revised
September, 1972

Representative George Darrow
Chairman

Fletcher E. Newby
Executive Director

Reprinted by Cooperative Extension Service, Montana State University, Bozeman, Montana.

[redacted]

COAL DEVELOPMENT POTENTIAL IN EASTERN MONTANA

by

Thomas J. Gill

REASONS FOR RENEWED INTEREST

Montana's coal reserves are again becoming economically important after 15 years of relative inactivity. The primary reasons for the recent renewed interest are the vast quantities available as well as the chemical properties of the coal. It is low in sulfur, sodium, and ash and is non-agglomerating and chemically reactive. Also of significance is the intimate relationship between coal and water supplies, the low cost of shipping through unit trains, increased demand for electricity, and recent advances in coal hydrogenation (7).

In the eastern portion of Montana underlain by coal, a combination of angular sandstone-capped buttes, deeply dissected badlands, rolling hills, and dry climate has resulted in a population density of about one person per square mile and an economy based primarily on livestock. The area contains little industry, few towns of more than 2,500 people, and a limited amount of dry and irrigated farming where the terrain permits, but a great majority of the land is devoted to livestock grazing.

GEOLOGY AND RESERVES

The coal basin, which consists of parts of four states and Saskatchewan, is known as the Fort Union area, named after the formation in which the coal is found. It is Paleocene in age and consists of sandstones, siltstones, claystones, and numerous coal beds in an interlayered sequence. The coal-bearing portion of the Fort Union Formation is primarily of fluvial origin,

containing sediments derived from the Rocky Mountains to the west. The terrain on which these sediments were deposited was a low floodplain that contained large subsiding swampy areas and was crossed by numerous meandering streams.

The Fort Union area is perhaps the largest coal basin in the world, containing 40 percent of the United States reserves. Total reserves have been estimated to be 1.3 trillion tons (11), with strippable reserves in Montana calculated to be more than 30 billion tons (8).

Strippable coal is defined as a seam having a minimum thickness of six feet and overlain by 150 feet or less of overburden. It must be relatively free of shale partings and of sufficient areal extent to allow economic production (3).

WATER AVAILABILITY

Water controls all activity in this semiarid region, and the industrial future of the Fort Union coal fields is no exception because coal-based development requires enormous quantities of water for cooling and conversion. Because most of the coal fields are far removed from existing surface water sources, the nature and extent of development would depend on the quantity of water made available at the mine site. A large volume of easily accessible water would allow extensive generating and conversion complexes. If this supply is not provided through several new storage facilities and an intricate system of government pipelines, development would be more restricted and probably concentrated on mining and export of coal.

The future use of groundwater in coal field development has not yet been firmly established. Evidently very little deep exploratory drilling for water has been done, although the Montana Power Company has drilled to a depth of about 9,300 feet into Mississippian sediments near Colstrip. The chemical

suitability of the water varies, but the deliverability of the well looks favorable. It taps three aquifers and flows at a rate of 60 gallons per minute (9). However, the Montana Bureau of Mines indicates that groundwater resources are not adequate to facilitate large-volume industrial development (7).

Surface water sources in the Montana Fort Union area are the Missouri, Yellowstone, Powder, Tongue, Bighorn, and Little Bighorn Rivers. Industrial utilization requires flow control on the streams from which installations draw their supply. This control is obtained through the use of dams and offstream storage reservoirs. Storage facilities in the general area include Bighorn Lake, Tongue River Reservoir, Fort Peck Reservoir, and the proposed Moorhead Reservoir on the Powder River. The Bureau of Reclamation is also considering Allenspur Dam on the Yellowstone River and two offstream reservoirs on the north side of the river between Forsyth and Billings. A summary of available and potential industrial water from each source is as follows (17):

	Acre-feet	
	Available	Potential
Bighorn River		
Bighorn Lake	262,000	
Powder River		
Moorhead Reservoir		57,000
Tongue River		
Tongue River Reservoir		60,000
Yellowstone River		
Mainstem (with regulation by offstream reservoirs or Allenspur)		1,356,000
Missouri River (15)		
Fort Peck Reservoir	1,000,000 (approximately)	

The Bureau of Reclamation has proposed an aqueduct system for the purpose of providing water for coal development. The agency investigated several routes

and delivery points with the primary Montana termini in the areas of Colstrip, Sarpy Creek, Sweeney Creek, Crooked Creek, and Pumpkin Creek. In response to an inquiry, some of the potential users exhibited a definite interest and indicated that total aqueduct capacity should be about 2.6 million acre-feet per year (9). The earliest request delivery date was 1977, with the majority of the firms listing 1980 as the target date for completion of the system (6).

A significant quantity of water is present on Indian lands in Montana. To how much of this the Indians would be entitled is still undetermined, although it is expected that they would be first in line. The Indians' share would provide a marketable product for the tribes involved, but the anticipated legal battle would have to be settled prior to construction of the aqueduct.

A shortage of water is developing in eastern Montana, especially in the Yellowstone River drainage. The Bureau of Reclamation (16) indicates that 871,000 to 1,004,000 acre-feet of water per year from Montana's portion of the Yellowstone, Bighorn, Powder, and Tongue Rivers are presently under option by energy companies. The agency has also received requests or indications of interest in another 945,000 acre-feet from these streams (17). The appraisal report on Montana-Wyoming aqueducts indicates that the state's total existing and potential supply of water from these sources amounts to 1,735,000 acre-feet per year. Fort Peck Reservoir on the Missouri River has about one million acre-feet of available water that will probably be used as a source for any installations north of the Yellowstone. Additional storage development on the Missouri, such as the proposed High Cow Creek Dam, could expand the supply of industrial water.

In general, it seems safe to assume that a supply of water sufficient to accommodate the coal developments currently under consideration would require complete development of the area's water resources. This would not only mean

more dams, but interbasin and interstate transportation of water through the network of pipelines proposed by the Bureau of Reclamation. Before construction begins, the benefit derived from such action should be carefully weighed against other possible uses of the water as well as cumulative primary and secondary environmental impacts. In this area of vast strippable coal deposits, water is the key, whether for production of synthetic crude oil, synthetic pipeline gas, byproduct chemicals, or electric power generation. Provision of a readily available water supply would have far-reaching effects -- environmentally, socially, and economically.

RECENT DEVELOPMENTS

Coal companies now operating strip mines in Montana include the following:

Western Energy at Colstrip began production in 1968 at a rate of half a million tons per year. The operation has expanded to an estimated five million tons in 1971 (11). A recent announcement indicates that the company intends to provide a Wisconsin power firm with 2.3 million tons per year.

Peabody Coal Company opened a test pit seven miles south of Colstrip in 1968. The company plans to supply Minnesota Power and Light with two million tons of rosebud coal annually.

Decker Coal Company is expected to mine about 3.4 million tons in 1972 near the community of Decker in southeastern Big Horn County (11). A railroad spur linking Decker with northern Wyoming has recently been completed. Shipping costs are reduced through use of a unit train on which coal is the only commodity transported. The rate per ton varies with the quantity of coal to be delivered and the distance to destination.

Knife River Coal is operating in the eastern part of the state near Savage. The company produces about 320,000 tons of coal per year and disturbs 20 additional acres of land per year (10).

Consolidation Coal Company has a pit in the Bull Mountains from which it removed 39,000 tons for a test burn in 1971.

The next mining operations are likely to be (11) Peabody Coal on the Northern Cheyenne Indian Reservation, Consolidation Coal in the Bull Mountains, and Westmoreland Resources on Sarpy Creek.

Montana's coal basin has undergone intense leasing activity. Many companies and private individuals have taken leases on state land, with Consolidation Coal, Ayrshire Coal, Fred Woodson, and Peter Kiewit & Sons heading the list. The Montana office of the Bureau of Land Management has issued 37 leases embracing 52,588 acres. Seventeen of these leases are in Montana. Production has begun on only 12 of the total, amounting to approximately 1.5 million tons in 1971. In addition to these leases, there are 14 valid prospect permits embracing 37,544 acres.

The BLM also had under consideration 119 applications for prospect permits by 20 applicants, affecting 419,684 acres. The bureau denied these applications, stating, "...there is no compelling need, at this time, to encourage further prospecting for a resource when there is already a known supply under lease that is waiting to be developed" (21).

About 16,000 acres of Indian land have also been leased. Two costs are involved here, a lease fee and a development cost similar to the improvement requirement on a locatable mineral claim. After a certain number of years, following review by the U. S. Department of Interior and the Bureau of Indian Affairs, a lease can be canceled if mining operations have not begun. The grace period is usually about 10 years.

Coal-fired steam generation plants presently operating in the state are located in Billings and Sidney. Montana Power has begun construction of a 700-megawatt mine-mouth plant at Colstrip, the first 350-megawatt unit of which is scheduled to be completed in 1975 (2). Two additional 700-megawatt units have been proposed for the Colstrip site.

WHAT DOES THE FUTURE HOLD IF WE HAVE...

Strip Mining and Export?

The Montana Bureau of Mines and Geology indicates that 1973 coal production in this state will be about 16 million tons and that it will be expanded to more than 20 million tons annually by 1975 (8, 11). The increasing demand for low-sulfur coal could accelerate strip-mining activity and lead to significantly higher production figures in the near future.

With proliferation of strip mining comes the problem of large-scale reclamation. Extraction of 16 million tons of coal per year from the present mines will overturn 275 to 520 acres of land per year, while full employment of Montana's strippable reserves would disturb a total of about 770,000 acres (20). Although eastern Montana does not have problems with such things as acid drainage, reclamation efforts are complicated by the semiarid conditions of the region. The scarcity of water makes regrowth of any type of vegetation a very slow process. Previous experience shows that unconsolidated spoils left at the angle of repose will not support an effective vegetative cover and that simply leveling the tops of the spoils will do little to alleviate the problem; however, stockpiling soil, contouring spoils, and subsequent use of farm equipment for soil conditioning and seeding offer some possibilities.

In such areas as Decker, in which the coal bed is an aquifer, mining will have a definite impact on groundwater supply, movement, and rate of recharge. A well near the test pit at Decker lost five feet of head after excavation, and evidence indicates that all water will eventually be drained from the coal bed aquifer. Wells will have to be deepened to tap other aquifers as mining progresses. Because spoils have lower permeability than the coal bed, cessation of mining and filling the final cut will restrict groundwater movement and raise the water table up-gradient from the mine site. After reclamation, the mined area might serve as a zone of local recharge.

Assuming that reclamation is effective, there would still be a considerable delay before land could be returned to its original use. Until the vegetative cover is firmly established, grazing would be impossible. Wildlife would be displaced for an unknown period, with no assurance that the subsequent habitat created on the spoils would satisfy all the needs of native species.

Strip mining and export would cause other environmental problems. Among these are a dust problem, at least temporarily, in the mining area and vicinity and additional railroad corridors if the coal is shipped by unit train. If coal-slurry pipelines are used, large quantities of Montana water will be exported, causing possible local depletion.

Because of the high degree of mechanization in the mining and transportation processes, development for export would probably cause only a small increase in job opportunities and no significant change in the area's overall employment pattern.

Mine-mouth Generating Plants

The requirements for a mine-mouth generating installation are: proximity to fuel source, market, or both; access to large supplies of cooling water; freedom from floods or other predictable natural disasters; and a large tract of land available at a moderate cost. Eastern Montana meets all the requirements except market, and the development of extra-high-voltage grids would provide that.

The North Central Power Study (12) estimates a steam-fired generating capacity of 53,000 megawatts in the Gillette-Colstrip oval by 1980. The complex would provide electricity within a 13-state area and for users as far away as St. Louis, Missouri. Something less than half of the capacity would probably be generated in Montana, which contains 21 of the 42 potential sites.

The plants range in size from 1,000 to 10,000 megawatts (The Corette plant in Billings is 180 megawatts), with total estimated coal consumption in excess of 200 million tons per year. About 300-500 full-time employees would be required to operate the Montana plants. These would be in addition to personnel needed for maintenance and service of transmission lines and operation of the mines.

Full development of all 21 North Central Power Study sites in eastern Montana would result in an instate steam-generating capacity of about 69,000 megawatts. Most of the Montana plants would be in the 1,000 and 5,000-megawatt categories, while a large percentage of the Wyoming installations would have 10,000 megawatt outputs.

One of the serious problems associated with the plants is that of airborne contaminants. Even with the most advanced pollution control equipment, enormous amounts of pollutants would be introduced into the atmosphere as a result of the vast quantity of coal used. Electrostatic precipitators and wet scrubbers can remove 99 plus percent by weight of the particulate matter but a much smaller percentage of fine material (less than one micron in diameter). Unfortunately, it is the fines that stay suspended longest, enter most easily and deeply into the lungs, and inhibit visibility. Suspended particles also reflect solar radiation and may seed storms and otherwise alter downwind weather patterns (14). A current example of the problems is the 2,075-megawatt Four Corners plant at Farmington, New Mexico, which in early 1971 emitted over 465 tons of particulates each day and whose plume of pollution could be traced back to the plant from a distance of 140 miles (19). The magnitude of the future problem can be foreseen when it is realized that several of the North Central Power Study plants proposed for Montana are two and a half to five times as large as the Farmington operation.

Much conflict exists concerning the effects of sulfur dioxide, a major emission from coal-burning operations. Evidence indicates that exposure to SO_2 has a retardation effect on plant growth and can be a threat to human health. Of sulfur dioxide in the air, President Nixon's February 1971 message to Congress states:

> Sulfur oxides are among the most damaging air pollutants. High levels of sulfur oxides have been linked to increased incidence of such diseases as bronchitis and lung cancer. In terms of human health, vegetation, and property, sulfur oxide emissions cost society billions annually.

Although we have not been able to locate any extensive studies concerning the effects of SO_2 on range vegetation, reports of deteriorated flora make it clear that injury can occur in areas of low annual concentrations when the sources of pollution and/or meteorological conditions are such that the threshold for injury is exceeded. Evidence also indicates chronic injury where concentrations never exceeded 0.1 parts per million (18). One investigator, experimenting with the effect of SO_2 on rye grass, reported that yields grown in unfiltered air were significantly lower than similar plants grown in filtered air, with no visible symptoms in the plants. Sulfur dioxide levels ranged from 0.01 ppm to 0.06 ppm, with exposure periods ranging from 46 to 81 days (18).

At concentrations of about 0.05 ppm to 0.25 ppm, sulfur dioxide may react synergistically with ozone or nitrogen dioxide in short-term exposures to produce moderate to severe injury to sensitive plants. The damage caused by the combination of SO_2 and ozone or SO_2 and NO_2 is much more severe than would be a similar concentration of SO_2 and NO_2 individually (18).

These mine-mouth installations would also release large amounts of carbon dioxide as well as varying amounts of uranium, radium, thorium, mercury, cadmium, other heavy metals, and trace elements.

Direct emissions are not the only serious environmental problems created by mine-mouth plants. Blowdown water (water that has been used in cleaning the cooling mechanism) is highly charged with minerals that are capable of killing aquatic life and surface vegetation. These minerals can also contaminate groundwater if leaching occurs. Spoilbanks are yet another source of dissolved solids if water in excess of the normal precipitation (10-15 inches) is applied. Fly ash, removed by the pollution control equipment and disposed in the spoils, contains a number of heavy metals and trace elements, including lead, zinc, copper, sulfur, and boron. These elements, toxic at certain levels, are evidently not inert when buried and exposed to water.

Transmission lines associated with mine-mouth plants are a major aesthetic intrusion on the landscape. Corridors, excavations, and access roads as well as the towers themselves cause not only visual but ecological degradation. Pipelines for water supply have similar though less severe impacts.

Conversion Plants and Multiproduct Complexes?

A multiproduct complex consists of one integrated operation to produce electricity, liquid and gaseous fuels, and petrochemicals. These plants would have a capacity of 1,000 megawatts of power generation, 50,000 to 100,000 barrels of liquid fuel per day, and 250 million cubic feet of gas per day. Each plant would consist of a carbonization section producing gas and liquid fuels and a hydrogenation unit producing synthetic crude oil. Char, a byproduct of the carbonization process, is usable as a fuel in the power plant. A three-plant complex would require 50,000 to 75,000 acre-feet of water annually and 12.5 million to 18 million tons of coal (15). The tremendous water and coal requirements would probably limit the number of complexes in Montana to 12 or less (16).

Gasification would probably be the first type of coal conversion in Montana. A synthetic pipeline gas would have to be approximately the same quality as

natural gas, meaning a heating value of 950-plus BTU's per cubic foot (13). Sixty-five gasification processes presently exist (15), but none can yet produce at a price competitive with natural gas. The German Lurgi process probably offers the most promise for commercial gasification because fewer steps are needed. It requires larger capital investments than other techniques but has been proven in more than 30 plants around the world, none in the United States.

Lurgi gasification plants may consist of four units (trains) having a total capacity of one billion cubic feet per day and requiring a total investment of about $1 billion. The trains located seven to 10 miles apart and each would consume about seven million tons of subbituminous coal as well as 17,000 acre-feet of water per year. This method makes more efficient use of the coal's original energy content than do steam electric installations. Steam generators transform 30 to 40 percent of the coal's heat into electricity, while the Lurgi coal to gas process has a 69-percent conversion factor (efficiency). Preliminary estimates indicate that Lurgi gas plants could be operable in the Fort Union area within the next decade.

Several companies have expressed interest in constructing one or more gasification units of 250 million cubic feet per day in Montana, but the intended gasification techniques have not yet been made public. In December of 1971 the HFC Oil Company of Casper, Wyoming requested 50,000 acre-feet of water from the Missouri River for future use in two or more gasification plants near Bloomfield in Dawson County. One may be constructed as early as 1974. Colorado Interstate Gas Company is slated to build a similar plant near Hardin, Montana. A proposed gasification plant near Sarpy Creek on the Crow Indian Reservation is expected to be operational by 1984 (16). Coal requirements would probably remain about the same regardless of the process used, but water requirements could vary significantly. Some estimates of the water needs for a plant capacity of 250 million cubic feet per day go as high as 33,000 acre-feet per year.

Several coal liquefaction processes have been devised and are in various stages of development, but as yet are noncompetitive with petroleum products. These plants would have to produce approximately 100,000 barrels of liquid fuel per day and would consume annually 11 to 15 million tons of coal and 65,000 acre-feet of water (4, 15). No liquefaction plants are currently known to be planned for Montana.

The total instate population increase resulting from coal development might be 300 thousand to 400 thousand people (1, 5). One multiproduct complex would employ more than 3,000 people and might create a city as large as 24,000, which is much larger than any present Montana city east of Billings (17).

The primary environmental problems created by multiproduct complexes would be the same as those previously mentioned.

IMPACT ON THE HUMAN ENVIRONMENT

The human environment is made up of numerous systems including industrial, agricultural, residential, commercial, educational, recreational, and political, as well as systems of cultural amenities, communications, and transportation (5). All these systems are interrelated and any change within one is reflected by corresponding secondary changes in the others. It is therefore apparent that intensive large-scale development in a predominantly agricultural region would have far-reaching secondary repercussions.

The transition from an agrarian to an urban-industrial life style could be very rapid in some locations. In these areas the basic employment patterns would be changed, the traditional culture values disrupted, and existing land use relationships altered. Well-planned coal development could perhaps benefit some eastern Montana communities whose populations have declined rapidly in recent years, but such benefits might be short-range.

Industrialization creates an increased tax base at all levels. More income and more property are available for taxation, but the population increase also creates a greater demand and requires greater expenditures for all government services, including police and fire protection, sewage and solid waste disposal, and water. It also requires a larger number of educational facilities, an expanded political system, and a rethinking and modification of the entire transportation system. It means a greatly increased load on all existing recreation facilities and a demand for more.

The increased tax base is often temporary in the case of coal mining and coal-related industry. Unless reclamation is unusually successful and the land is restored to a productive condition, strip mining destroys the base: when the coal is depleted and the power companies move their plants closer to new fuel supplies, spoilbanks have little tax value. The present standard of living in the Appalachian coal fields demonstrates the long-range economic impact of indiscriminate mining. The coal and power companies have departed, leaving the people with no jobs and the government with nothing to tax. With exhaustion of Montana's coal reserves, a similar situation would almost certainly develop. The lifetime of proposed generating facilities for Montana coal development is estimated to be about 30 years.

The coal development area of the state may also be faced with the stress and frustration of urban living along with other related problems such as an increased crime rate, poverty, overcrowding, noise, congestion, litter, and neighborhood deterioration.

WHAT MUST BE DONE?

The question of current versus future use must be carefully considered. Responsible development should include retaining mineable deposits as reserves. A state agency, possibly the Department of Lands, should be given the power of denial to restrict mining in areas such as the Bull Mountains and the Ashland

district of the Custer National Forest. Any kind of mining would be very destructive in these heavily wooded hills, but the topography and relief are such that the coal seam is exposed on the valley walls, thus requiring the most ruinous of all opencut techniques, contour stripping. Omission of these areas and others from the present coal development picture would preserve an energy source usable in the event of a severe future shortage. And if coal, as indicated by many, is only an interim solution to our energy problems, these productive, scenic, and historic areas might never have to be mined.

The present steam electric generators have half the efficiency of some other generation and conversion techniques, such as magnetohydrodynamics (MHD), now under study. Rapid development of these latter methods could render the present type of facilities obsolete in a short time. The long-range interests of Montana might best be served by delaying coal development for a number of years rather than irretrievably committing the state's resource to an inefficient, outdated technology.

Long-term social and environmental degradation can be avoided only through a coordinated effort by all levels of government, the involved companies, and an interested public to formulate regional plans. Halfhearted, fragmentary efforts by separate entities simply will not do the job.

A functional, soundly based regional plan relating to coal development requires a body of background information that is currently lacking. Urgently needed are:

1. A comprehensive study of effective reclamation practices.
2. A detailed analysis of Montana coal to determine the amount of trace elements and heavy metals present.
3. More work on the effects of SO_2 and other emissions on the rangeland ecology.

4. A study of the problems associated with burial of fly ash in spoilbanks.
5. An in-depth study of government and industry research priorities. It would be important to know how much is being spent on the search for more efficient and less degradatory means of electrical generation and transmission as well as for new generation techniques.
6. A comprehensive regional meteorological survey of the eastern one-third of the state.
7. Specific knowledge of the environmental problems involved in moving coal by slurry pipeline.

Above all, if the planning efforts of Montana and other coal reserve states are to have any hope of success, <u>the most imperative needs are for state self-determination in resource use and for a national energy policy and a national program to moderate energy consumption by encouraging conservative rather than maximum energy use</u>.

LITERATURE CITED

1. Aldrich, H. E. 1968. Industrial water sales in Montana. In Montana's coal resource situation. Mont. Bur. Mines Geol., report to the 1969 legislature, January, 1969.

2. Anderson, C. (Mont. Power Co.). 1971. Personal communication. December 21.

3. Blumer, J. W., G. Dahl, and R. Matson, 1969. Strippable coal deposits on state land, Powder River County, Montana. Mont. Bur. Mines Geol., Bull. 69.

4. Cochran, N. P. 1969. Project gas, oil, power. In proceedings of the Montana coal symposium, Billings.

5. Darrow, George. 1969. Seizing the opportunity for regional environmental planning. In proceedings of the Montana coal symposium, Billings.

6. Gibbs, P. Q. 1971. Remarks to federal and state agencies. Bur. of Rec., Billings.

7. Groff, S. L. and R. Matson. 1969. Montana's coal resource situation. Mont. Bur. Mines Geol., report to the 1969 legislature.

8. Groff, S. L. and R. Matson. 1972. Montana's coal resource situation. The Mining Record, 83(13):5.

9. Hoffman, R. (Dept. Natl. Res. and Cons.). 1971. Personal communication. Nov. 15.

10. Jordan, D. A. (Knife River Coal Co.). 1971. Personal communication. Nov. 26.

11. Matson, R. E. (Mont. Bur. Mines Geol.). 1971. Personal communication. Nov. 22.

12. North Central Power Study Coordinating Committee. 1971. Study of mine-mouth thermal power plants with extra-high-voltage transmission for delivery of power to load centers. Vol. 1.

13. Schora, F. C. 1969. Coal gasification. In proceedings of the Montana coal symposium, Billings.

14. U. S. Bureau of Land Management. 1971. Second draft environmental impact statement for the Jim Bridger thermal-electric generation project.

15. U. S. Bureau of Mines. 1972. Projected water requirements of new mineral industry in Powder River Basin, Montana and Wyoming. Prelim. report 187.

16. U. S. Bureau of Reclamation. 1972. Development in eastern Montana. Great Falls.

17. U. S. Bureau of Reclamation. 1972. Appraisal report on Montana-Wyoming aqueducts.

18. U. S. Department of Health, Education, and Welfare. 1969. Air quality criteria for sulfur oxides. Washington, D. C.

19. U. S. Senate Committee on Interior and Insular Affairs. 1971. Problems of electrical power production in the southwest.

20. Zaidlicz, E. (BLM state director). 1972. Conference on reclamation program for surface mined lands, Billings.

21. Zaidlicz, E. (BLM state director). 1972. Letter to Gulf Oil Corporation. August 11.